Executive Summary

This report, *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, National Sediment Quality Survey* describes the accumulation of chemical contaminants in river, lake, ocean, and estuary bottoms and includes a screening-level assessment of the potential for associated adverse effects on human and environmental health. The United States Environmental Protection Agency (EPA) prepared this report to Congress in response to requirements set forth in the Water Resources Development Act (WRDA) of 1992, which directed EPA, in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE), to conduct a comprehensive national survey of data regarding the quality of aquatic sediments in the United States. Section 503 of WRDA 1992 requires EPA to "compile all existing information on the quantity, chemical and physical composition, and geographic location of pollutants in aquatic sediment, including the probable source of such pollutants and identification of those sediments which are contaminated...." Section 503 further requires EPA to "report to the Congress the findings, conclusions, and recommendations of such survey, including recommendations for actions necessary to prevent contamination of aquatic sediments and to control sources of contamination." As part of this continuing program, EPA must submit a national sediment quality report to Congress every two years. This is the second report to Congress, the first report was completed in 1997.

To comply with this mandate, EPA's Office in Science and Technology (OST): 1) initiated the National Sediment Inventory (NSI) which is designed to compile sediment quality information from available electronic databases into one centralized, easily accessible location, and; 2)developed the *National Sediment Quality Survey* report.

Description of the NSI

The NSI includes approximately 4.6 million records of sediment chemistry, tissue residue, and toxicity data, for more than 50,000 monitoring stations across the country. To efficiently collect usable information for inclusion in the NSI, EPA sought data that were available in electronic format, represented broad geographic coverage, and represented specific sampling locations identified by latitude and longitude coordinates. Although EPA elected to evaluate in this report only data collected since 1990 (i.e., 1990-1999), data before 1990 are maintained in the NSI for comparison purposes. At a minimum, EPA required that electronically available data include monitoring program, sampling date, latitude and longitude coordinates, and measured units for inclusion in the data evaluation. The NSI includes data from the following data storage systems and monitoring programs:

- Selected data sets from EPA's Storage and Retrieval System (STORET)
- NOAA's Query Manager Data System
- State of Washington Department of Ecology's Sediment Quality Information System (SEDQUAL)
- Selected data sets from USGS's WATSTORE
- EPA's Environmental Monitoring and Assessment Program (EMAP)
- Data compiled for the previous report to Congress
- Chesapeake Bay Program
- Upper Mississippi River System data compilation prepared by the USGS
- Indiana Department of Environmental Management Sediment Sampling Program
- Oklahoma Reservoir Fish Tissue Monitoring Program, 1990-1998

- Houston Ship Channel Toxicity Study

NSQS Report Objective

The objective of the NSQS report is to develop screening-level assessment protocols to allow the identification of potentially contaminated sediment, to be produced biennially for Congress as well as the regions, states, and tribes on the incidence and severity of sediment contamination nationwide. The purpose of the initial report as well as this first update to that report is to depict and characterize the incidence and severity of sediment contamination based on the *probability* of adverse effects to human health and the environment. To accomplish this objective, EPA applied assessment protocols to existing available data in a uniform fashion. EPA intended to accurately depict and characterize the incidence and severity of sediment contamination based on the probability of adverse effects to human health and the environment. The process has demonstrated the use of "weight-of-evidence" measures (including measures of the bioavailability of toxic chemicals) in sediment quality assessment. Information contained in this report may be used to further investigate sediment contamination on a national, regional, and site-specific scale. Further studies may involve toxicological investigations, risk assessment, analyses of temporal and spatial trends, feasibility of natural recovery, and source control.

The initial report presented a national baseline screening-level assessment of contaminated sediments from sediment quality data collected from 1980 through 1993 using a weight-of-evidence approach. This report presents the results of the screening-level assessment of the NSI data from 1990 to 1999. Due to the biennial reporting requirements associated with this report, EPA wanted to 'window in' on a regular time frame for including data. One major advantage of screening out older data (data collected prior to January 1, 1990) for this report is to prevent the results from being unduly influenced by historical data when more recent data are available. However, this would not account for any decrease in sediment contaminant levels due to scouring, re-burial, natural attenuation, or active sediment remediation that have occurred since that sample was collected.

This current report identifies locations where available data indicate that direct or indirect exposure to the sediment could be associated with adverse effects to aquatic life and/or human health. Even though this report focuses on data collected from 1990 through 1999, conditions might have improved or worsened since the sediment was sampled. Additionally, the data were generally not collected in a randomized sampling approach. Consequently, this report does not and cannot provide a definitive assessment of the national condition or relative health of sediments across the country. Even though this report does not provide an assessment of the "national condition" of contaminated sediments it does evaluate data collected from 1980 through 1999 in the NSI database to assess changes in the extent and severity of sediment contamination over time for specific areas in the United States where sufficient data exists.

As mentioned above, this report provides a screening-level assessment outlining stations throughout the United States where the *probability* of adverse effects to human health and the environment exist. Since the data compiled for this report consist largely of non-random sampling events and do not provide complete national coverage, EPA has not developed a "national estimate" of the areal extent of contaminated sediments. Since the limitations of the data do not allow for a national estimate of the percentage of contaminated sediments, remediation decisions should not be made solely on the results of this report, nor should the report be used to estimate the national cost of potential sediment remediation. As the NSI database continues to expand and with an increased effort to randomly select sampling stations this may be possible in future reports to Congress.

Evaluation Approach

Section 503 of WRDA 1992 defines "contaminated sediment" as "aquatic sediment which contains chemical substances in excess of appropriate geochemical, toxicological, or sediment quality criteria or

measures; or is otherwise considered by the Administrator [of EPA] to pose a threat to human health or the environment....” The approach used to evaluate the NSI data focuses on the risk to benthic organisms exposed directly to contaminated sediments, and the risk to human consumers of organisms exposed to sediment contaminants. EPA evaluated sediment chemistry data, chemical residue levels in edible tissue of aquatic organisms, and sediment toxicity data taken at the same sampling station (where available) using a variety of assessment methods.

The following measurement parameters and techniques were used alone or in combination to evaluate the probability of adverse effects:

Aquatic Life

(1) Comparison of sediment chemistry measurements to draft equilibrium partitioning sediment guidelines (ESGs) derived from final or secondary acute values and final or secondary chronic values.

(2) Comparison of the molar concentration of acid volatile sulfides ([AVS]) in sediment to the molar concentration of simultaneously extracted metals ([SEM]) in sediment (under equilibrium conditions, sediment with [AVS] greater than [SEM] will not demonstrate toxicity from metals).

(3) Estimation of the predicted proportion toxic from sediment chemistry observations using a logistic regression model.

(4) Comparison of the total ESG toxic unit for PAHs to final chronic or acute values.

(5) Toxicity based on acute or chronic solid-phase sediment toxicity data.

Human Health

(6) Comparison of theoretical bioaccumulation potential (TBP) values derived from sediment chemistry to:

- EPA cancer and noncancer risk levels or
- Food and Drug Administration (FDA) tolerance, action, or guidance values in the absence of, or if more stringent than, EPA levels

(7) Comparison of fish tissue contaminant levels to:

- EPA cancer and noncancer risk levels or
- FDA tolerance, action, or guidance values in the absence of, or if more stringent than, EPA levels

The sediment chemistry screening values used in this report are not regulatory criteria, site-specific cleanup standards, or remediation goals. Sediment chemistry screening values are reference values above which a sediment ecotoxicological assessment might indicate a potential threat to aquatic life. The sediment chemistry screening values include both theoretically and empirically derived values. The theoretically derived screening values (e.g., ESG, [SEM]-[AVS]) rely on the physical/chemical properties of sediment and chemicals to predict the level of contamination that would not cause an adverse effect on aquatic life under equilibrium conditions in sediment. The empirically derived, or correlative approaches, (e.g., predicted proportion toxic) rely on paired field and laboratory data to relate incidence of observed biological effects to the dry-weight sediment concentrations. Correlative screening values can relate measured concentration to a probability of association with adverse effects, but do not establish cause and effect for a specific chemical. Toxicity data were used to classify sediment sampling stations based on their demonstrated toxicity to aquatic life in laboratory bioassays.

Under an assumed exposure scenario, theoretical bioaccumulation potential (TBP) and tissue residue data can indicate potential adverse effects on humans from the consumption of fish that become contaminated through exposure to contaminated sediment. TBP is an estimate of the equilibrium concentration (concentration that does not change with time) of a contaminant in tissues of aquatic

organisms if the sediment in question were the only source of contamination to the organism. At present, the TBP calculation can be performed only for nonpolar organic chemicals. The TBP is estimated from the concentration of contaminant in the sediment, the organic carbon content of the sediment, the lipid content of the organism, and the relative affinity of the chemical for sediment organic carbon and animal lipid content. This relative affinity is measured in the field and is called a biota-sediment accumulation factor (BSAF, as discussed in detail in Appendix B). In practice, field measured BSAFs can vary by an order of magnitude or greater for individual compounds depending on location and time of measurement. For this evaluation, EPA selected BSAFs that represent the central tendency, suggesting an approximate 50 percent chance that an associated tissue residue level would exceed a screening risk value.

Uncertainty is associated with site-specific measures, assessment techniques, exposure scenarios, and default parameter selections. Many mitigating biological, chemical, hydrological, and habitat factors may affect whether sediment poses a threat to aquatic life or human health. Because of the limitations of the available sediment quality measures and assessment methods, EPA characterizes this evaluation as a screening-level analysis. Similar to a potential human illness screen, a screening-level analysis should pick up potential problems and note them for further study. A screening-level analysis will typically identify many potential problems that prove not to be significant upon further analysis. Thus, classification of sampling stations in this analysis is not meant to be definitive, but is intended to be inclusive of potential problems arising from persistent metal and organic chemical contaminants. For this reason, EPA elected to evaluate data collected from 1990 to 1999 and to evaluate each chemical or biological measurement taken at a given sampling station individually. A single measurement of a chemical at a sampling station, taken at any point in time over the past 10 years, may have been sufficient to categorize the sampling station as having an increased probability of association with adverse effects on aquatic life or human health.

In this report, EPA associates sampling stations with their "probability of adverse effects." Each sampling station falls into one of three categories, or tiers:

- Tier 1: associated adverse effects on aquatic life or human health are probable.
- Tier 2: associated adverse effects on aquatic life or human health are possible.
- Tier 3: no indication of associated adverse effects (any sampling station not classified as Tier 1 or Tier 2; includes sampling stations for which substantial data were available, as well as sampling stations for which limited data were available).

The potential risk of adverse effects on aquatic life and human health is greatest in areas with a multitude of contaminated locations. The assessment of individual sampling stations is useful for estimating the number and distribution of contaminated spots and overall magnitude of sediment contamination in monitored waterbodies of the United States. However, a single "hot spot" might not pose a significant threat to either the benthic community at large or consumers of resident fish because the spatial extent of exposure could be small. On the other hand, if many contaminated spots are located in close proximity, the spatial extent and probability of exposure are much greater. EPA examined sampling station classifications within watersheds to identify areas of probable concern for sediment contamination (APCs), where the exposure of benthic organisms and resident fish to contaminated sediment might be more frequent. In this report, EPA defines watersheds by 8-digit United States Geological Survey (USGS) hydrologic unit codes, which are roughly the size of a county. Watersheds containing APCs are those in which 10 or more sampling stations were classified as Tier 1, and in which at least 75 percent of all sampling stations were categorized as either Tier 1 or Tier2.

The definition of "area of probable concern" was developed for this report to identify watersheds for which further study of the effects and sources of sediment contamination, and possible risk reduction needs, would be warranted. Where data have been generated through intensive sampling in areas of known or suspected contamination within a watershed, the APC definition should identify watersheds which contain even relatively small areas that are considerably contaminated. However, this designation

does not imply that sediment throughout the entire watershed, which is typically very large compared to the extent of available sampling data, is contaminated. On the other hand, where data have been generated through comprehensive sampling, or where sampling stations were selected randomly or evenly distributed throughout a sampling grid, the APC definition might not identify watersheds that contain small or sporadically contaminated areas. A comprehensively surveyed watershed of the size typically delineated by a USGS cataloging unit might contain small but significant areas that are considerably contaminated, but might be too large in total area for 75 percent of all sampling stations to be classified as Tier 1 or Tier 2. Limited random or evenly distributed sampling within such a watershed also might not yield 10 Tier 1 sampling stations. Thus, the process used to identify watersheds containing APCs may both include some watersheds with limited areas of contamination and omit some watersheds with significant contamination. However, given available data EPA believes it represents a reasonable screening analysis to identify watersheds where further study is warranted.

Whereas the Tier 1, Tier 2, and Tier 3 evaluation benchmarks established in this report represent recent advances in sediment assessment techniques, they have been utilized in this report as a way to relate all the different data from all the different sources around the U.S. using common benchmarks. Therefore, the Tier 1, Tier 2, and Tier 3 benchmarks and interpretations used in this report are not currently appropriate for use in EPA regulatory programs that have developed their own frameworks and regulatory requirements, and were not designed to be a substitute for the various EPA program regulatory frameworks/authorities. EPA's regulatory programs (e.g., Office of Solid Waste and Emergency Response - OSWER) have developed their own scientifically defensible approaches to sediment evaluation based on the needs of their programs, and they will continue to utilize their current regulatory frameworks when making decisions regarding potentially contaminated sediments (e.g., sediment remediation, sediment disposal).

Strengths and Limitations

For this report to Congress, EPA has compiled the most extensive database of sediment quality information currently available in electronic format. To evaluate these data, EPA has applied sediment assessment techniques in a weight-of-evidence approach recommended by national experts. The evaluation approach uses sediment chemistry, tissue residue, and toxicity test results. The assessment tools employed in this analysis have been applied in North America, with results published in peer-reviewed literature. Toxicity test data were generated using established standard methods employed by multiple federal agencies. The evaluation approach addresses potential impacts on both aquatic life and human health. Some chemicals pose a greater risk to human health than to aquatic life; for others, the reverse is true. By evaluating both potential human health and aquatic life impacts, EPA has ensured that the most sensitive endpoint is used to assess environmental impacts.

Two general types of limitations are associated with this report to Congress-limitations of the compiled data and limitations of the evaluation approach. Limitations of the compiled data include the mixture of data sets derived from different sampling strategies, incomplete sampling coverage, the age and quality of data, and the lack of measurements of important assessment parameters. Limitations of the evaluation approach include uncertainties in the interpretive tools to assess sediment quality, use of assumed exposure potential in screening-level quantitative risk assessment (e.g., fish consumption rates for human health risk), and the subsequent difficulties in interpreting assessment results. These limitations and uncertainties are discussed in detail in Chapter 2 of this volume under "Limitations of the NSI Data Evaluation."

Data compiled for this report were generated using a number of different sampling strategies. Component sources contain data derived from different spatial sampling plans, sampling methods, and analytical methods. Most of the NSI data were compiled from nonrandom monitoring programs. Such monitoring programs focus their sampling efforts on areas where contamination is known or suspected to

occur. Reliance on these data is consistent with the stated objective of this survey: to identify those sediments which are contaminated. However, one cannot accurately make inferences regarding the overall condition of the Nation's sediment, or characterize the "percent contamination," using the data in the NSI database due to the incomplete National sampling coverage and because uncontaminated areas are most likely substantially underrepresented.

Because this analysis is based only on readily available electronically formatted data, contamination problems exist at some locations where data are lacking. Conversely, older data might not accurately represent current sediment contamination conditions. The reliance on readily available electronic data has undoubtedly excluded a vast amount of information available from sources such as local and state governments and published academic studies. In addition, some data in the NSI database were not evaluated because of questions concerning data quality or because no locational information (latitude and longitude) was available. NSI data do not evenly represent all geographic regions in the United States, nor do the data represent a consistent set of monitored chemicals.

EPA recognizes that sediment is dynamic and that great temporal and spatial variability in sediment quality exists. Movement of sediment is highly temporal, and dependent upon the physical and biological processes at work in the watershed. Some deposits will redistribute while others will remain static unless disturbed by extreme events. Because the data analyzed in this report were collected over a relatively long period of time, conditions might have improved or worsened since the sediment was sampled. Consequently, this report does not definitively assess the current condition of sediments, but serves as a baseline for future assessments.

The lack of data required to apply some important assessment parameters hampered EPA's efforts to determine the incidence and severity of sediment contamination. For example, the component databases contain a dearth of total organic carbon (TOC) and acid volatile sulfide (AVS) measurements relative to the abundance of contaminant concentration measurements in bulk sediment. TOC and AVS are essential pieces of information for interpreting the bioavailability, and subsequent toxicity, of nonpolar organic and metal contaminants, respectively. In addition, matched sediment chemistry with toxicity tests, and matched sediment chemistry with tissue residue data, were typically lacking.

It is important to understand both the strengths and limitations of this analysis to appropriately interpret and use the information contained in this report. The limitations do not prevent intended uses, and future reports to Congress on sediment quality will contain less uncertainty. To ensure that future reports to Congress accurately reflect current knowledge concerning the conditions of the Nation's sediment as our knowledge and application of science evolve, the NSI will develop into a periodically updated, centralized assemblage of sediment quality measurements and state-of-the-art assessment techniques.

Findings

EPA evaluated 19,470 sampling stations nationwide as part of the NSI data evaluation. Of the sampling stations evaluated, 7,600 stations (39 percent) were classified as Tier 1, 6,281 (32 percent) were classified as Tier 2, and 5,589 (29 percent) were classified as Tier 3. The percentage of all NSI sampling stations where associated effects are "probable" or "possible" (i.e., 39 percent in Tier 1 and 32 percent in Tier 2) does not represent the overall condition of sediment across the country: it could be expected that the overall extent of contaminated sediment is much less, as is the percentage of sampling stations where contamination is expected to actually exert adverse effects. This is primarily because most of the NSI data were obtained from monitoring programs targeted toward areas of known or suspected contamination (i.e., sampling stations were not randomly selected).

The NSI sampling stations were located in 5,695 individual river reaches (or water body segments) across the contiguous United States, or approximately 8.8 percent of all river reaches in the country

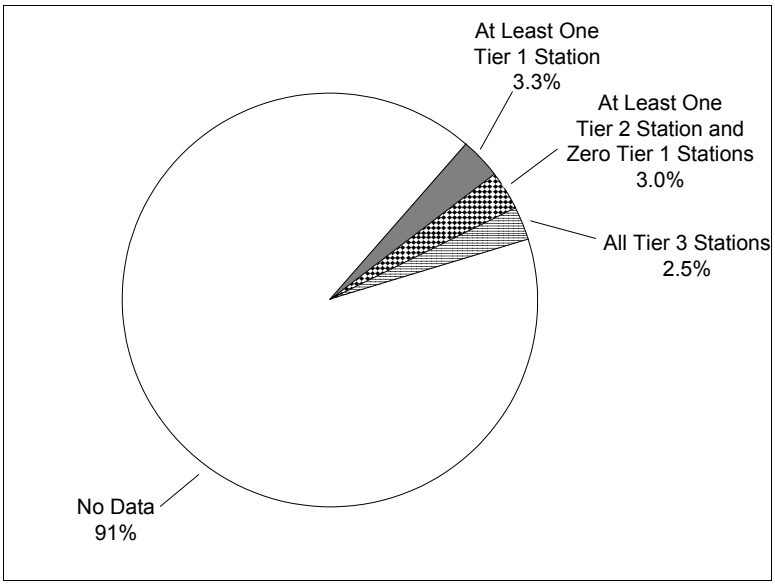

Figure 1. National Assessment: Percent of River Reaches That Include Tier 1, Tier 2, and Tier 3 Sampling Stations.

(based on EPA's River Reach File 1). A river reach can be part of a coastal shoreline, a lake, or a length of stream between two major tributaries ranging from approximately 1 to 10 miles long. As depicted in Figure 1, approximately 3.3 percent of all river reaches in the contiguous United States had at least one station categorized as Tier 1, approximately 3 percent of reaches had at least one station categorized as Tier 2 (but none as Tier 1), and all of the sampling stations were classified as Tier 3 in about 2.5 percent of reaches.

Watersheds containing areas of probable concern for sediment contamination (APCs) are those that include at least 10 Tier 1 sampling stations and in which at least 75 percent of all sampling stations were classified as either Tier 1 or Tier 2. The NSI data evaluation identified 88 watersheds throughout the United States as containing APCs (Figure 2 and Table 1). (The map numbers listed on Table 1 correspond to the numbered watersheds identified in Figure 2.) These watersheds represent about 4 percent of all watersheds in the United States (88 of 2,111). APC designation could result from extensive sampling throughout a watershed, or from intensive sampling at a single contaminated location or a few contaminated locations. In comparison to the overall results presented on Figure 1, 23 percent of reaches in watersheds containing APCs have at least one Tier 1 sampling station and 8 percent have no Tier 1 sampling station but at least one Tier 2 sampling station. In many of these watersheds, contaminated areas may be concentrated in specific river reaches in a watershed. Within the 88 watersheds containing APCs across the country, 86 individual river reaches or waterbody segments have 10 or more Tier 1 sampling stations.

The evaluation results indicate that sediment contamination associated with probable or possible adverse effects exists for both aquatic life and human health. Overall, a comparable number of stations were classified as Tier 1 using aquatic life evaluation parameters (4,996 stations) as human health evaluation parameters (5,128 stations). About twice as many stations were classified as Tier 2 using aquatic life evaluation parameters (8,019 stations) as human health evaluation parameters (3,999 stations).

Recognizing the imprecise nature of some assessment parameters used in this report, Tier 1 sampling stations are distinguished from Tier 2 sampling stations based on the magnitude of a contaminant concentration in sediment, or the degree of corroboration among the different types of sediment quality measures. In response to uncertainty in both biological and chemical measures of sediment

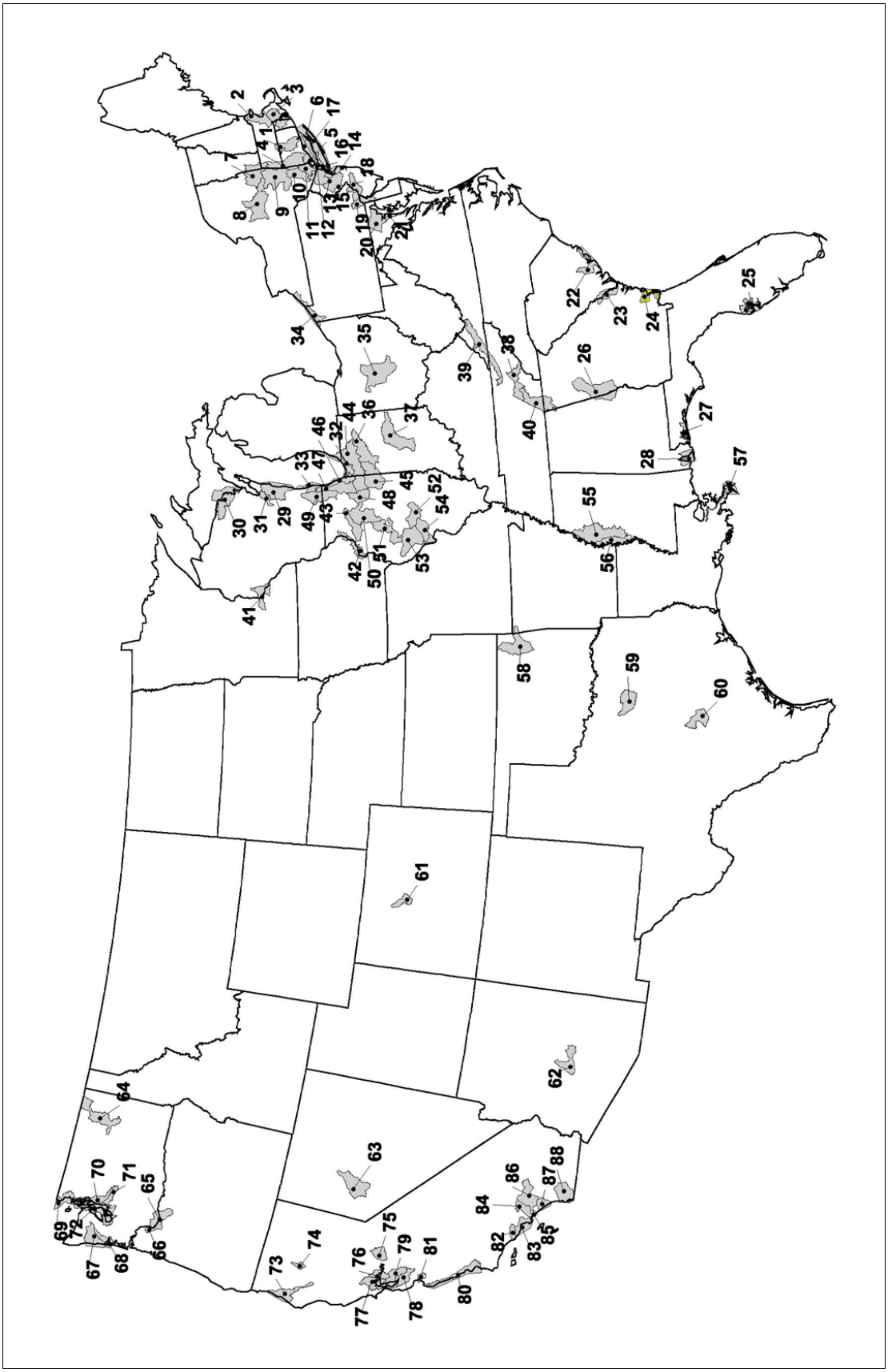

Figure 2. Watersheds Identified as Containing APCs.

Table 1. USGS Cataloging Unit Number and Names for Watersheds Containing APCs.

Map No.	Cataloging Unit Number	Cataloging Unit Name	Map No.	Cataloging Unit Number	Cataloging Unit Name
1	01080205	Lower Connecticut	45	07120002	Iroquois
2	01090001	Charles	46	07120003	Chicago
3	01090004	Narragansett	47	07120004	Des Plaines
4	01100005	Housatonic	48	07120005	Upper Illinois
5	01100006	Saugatuck	49	07120006	Upper Fox
6	01100007	Long Island Sound	50	07130001	Lower Illinois-Senachwine Lake
7	02020003	Hudson-Hoosic	51	07130003	Lower Illinois-Lake Chautauqua
8	02020004	Mohawk	52	07130007	South Fork Sangamon
9	02020006	Middle Hudson	53	07130011	Lower Illinois
10	02020008	Hudson-Wappinger	54	07130012	Macoupin
11	02030101	Lower Hudson	55	08030207	Big Sunflower
12	02030102	Bronx	56	08030209	Deer-Steele
13	02030103	Hackensack-Passaic	57	08090100	Lower Mississippi-New Orleans
14	02030104	Sandy Hook-Staten Island	58	11070209	Lower Neosho
15	02030105	Raritan	59	12030102	Lower West Fork Trinity
16	02030201	Northern Long Island	60	12090205	Austin-Travis Lakes
17	02030202	Southern Long Island	61	14010002	Blue
18	02040202	Lower Delaware	62	15060106	Lower Salt
19	02040205	Brandywine-Christina	63	16050203	Carson Desert
20	02060003	Gunpowder-Patapsco	64	17020001	Franklin D. Roosevelt Lake
21	02060004	Severn	65	17080001	Lower Columbia-Sandy
22	03050202	South Carolina Coastal	66	17090012	Lower Willamette
23	03060109	Lower Savannah	67	17100102	Queets-Quinault
24	03070203	Cumberland-St. Simons	68	17100105	Grays Harbor
25	03100206	Tampa Bay	69	17110002	Strait of Georgia
26	03130002	Middle Chattahoochee-Lake Harding	70	17110012	Lake Washington
27	03140105	Pensacola Bay	71	17110013	Duwamish
28	03160205	Mobile Bay	72	17110019	Puget Sound
29	04030101	Manitowoc-Sheboygan	73	18010102	Mad-Redwood
30	04030108	Menominee	74	18020112	Sacramento-Upper Clear
31	04030204	Lower Fox	75	18040005	Lower Cosumnes-Lower Mokelumne
32	04040001	Little Calumet-Galien	76	18050001	Suisun Bay
33	04040002	Pike-Root	77	18050002	San Pablo Bay
34	04120101	Chautauqua-Conneaut	78	18050003	Coyote
35	05060001	Upper Scioto	79	18050004	San Francisco Bay
36	05120106	Tippecanoe	80	18060006	Central Coastal
37	05120201	Upper White	81	18060011	Alisal-Elkhorn Sloughs
38	06010201	Watts Bar Lake	82	18070103	Calleguas
39	06010205	Upper Clinch	83	18070104	Santa Monica Bay
40	06020001	Middle Tennessee-Chickamauga	84	18070106	San Gabriel
41	07040001	Rush-Vermillion	85	18070201	Seal Beach
42	07080101	Copperas-Duck	86	18070203	Santa Ana
43	07090007	Green	87	18070301	Aliso-San Onofre
44	07120001	Kankakee	88	18070304	San Diego

contamination, environmental managers must balance Type I errors (false positives: sediment classified as posing a threat that does not) with Type II errors (false negatives: sediment that poses a threat but was not classified as such). In screening analyses, the environmentally protective approach is to minimize Type II errors, which leave toxic sediment unidentified. To achieve a balance and to direct attention to areas most likely to be associated with adverse effects, Tier 1 sampling stations are intended to have a high rate of "correct" classification (e.g., sediment definitely posing or definitely not posing a threat) and a balance between Type I and Type II errors. On the other hand, to retain a sufficient degree of environmental conservatism in screening, Tier 2 sampling stations are intended to have a very low number of false negatives in exchange for a large number of false positives.

One recommendation from the previous Report to Congress was to "consider whether to design future evaluations of NSI data to determine the temporal trends of contamination." To accomplish this, EPA evaluated surficial sediment data from the entire NSI database (data from 1980 through 1999). The evaluation of historical surficial sediment data is limited due to the heterogeneous nature of monitoring programs and available data. Nevertheless the evaluation tended to show decreased or no change in sediment contamination in most regions where data were available. The USGS National Water-Quality Assessment (NAWQA) program also examined trends in sediment contamination by reconstructing water-quality histories using lake and reservoir sediment cores from 22 locations nationally. Statistically significant increasing trends in total PAH concentrations occur at nine lakes and significant decreasing trends at two lakes were detected. The analysis of the organochlorine compounds (pesticides and PCBs) showed that only a few locations had significant trends since 1975. However, since 1965, significant decreasing trends in total DDT occur at 12 of the 22 lakes. Among the organochlorine compounds, dieldrin and chlordane have increased in almost as many lakes as they have decreased since 1975. The most consistent trend since the mid-1970s for any of the constituents tested is that all 22 lakes had statistically significant decreasing trends in lead concentrations. Two other trace elements had somewhat consistent trends; chromium and nickel each increased in only one lake and decreased in 9 and 8 lakes, respectively. Three other elements, arsenic, copper, and mercury, had significant trends in 10 or more lakes, all with more decreasing trends than increasing. The only trace element with more increasing trends than decreasing trends was zinc. Nine of the 19 urban lakes had increasing trends in zinc and 4 lakes had decreasing trends.

Conclusions

The characteristics of the NSI data, as well as the degree of certainty afforded by available assessment tools, allow neither an absolute determination of adverse effects on human health or the environment at any location, nor a definitive determination of the areal extent of contamination on a national scale. However, the evaluation results strongly suggest that sediment contamination may be significant enough to pose potential risks to aquatic life and human health in some locations. The evaluation methodology was designed for the purpose of a screening-level assessment of sediment quality; further evaluation would be required to confirm that sediment contamination poses actual risks to aquatic life or human health for any given sampling station or watershed.

The results of the NSI data evaluation must be interpreted in the context of data availability. Many states and EPA Regions appear to have a much greater incidence of sediment contamination than others. To some degree, this appearance reflects the relative abundance of readily available electronic data, not necessarily the relative incidence of sediment contamination.

Although the APCs were selected by means of a screening exercise, EPA believes that they represent the highest priority for further ecotoxicological assessments, risk analysis, temporal and spatial trend assessment, and contaminant source evaluation because of the preponderance of evidence in these areas. Although the procedure for classifying APCs using multiple sampling stations was intended to minimize the probability of making an erroneous classification, further evaluation of conditions in watersheds

containing APCs is necessary because the same mitigating factors that might reduce the probability of associated adverse effects at one sampling station might also affect neighboring sampling stations.

EPA chose the watershed as the unit of spatial analysis because many states and federal water and sediment quality management programs, as well as data acquisition efforts, are centered on this unit. This choice reflects the growing recognition that activities taking place in one part of a watershed can greatly affect other parts of the watershed, and that management efficiencies are achieved when viewing the watershed holistically. At the same time, the EPA recognizes that contamination in some reaches in a watershed does not necessarily indicate that the entire watershed is affected. Further analysis should be conducted within APC watersheds to delineate sediment contamination. This will allow sediment management activities determined to be necessary be performed in the most effective (cost as well as environmentally) and sound manner.

Watershed management is a critical component of community-based environmental protection using watershed or hydrologic boundaries to define the problem area. Many public and private organizations are joining forces and creating multi-disciplinary and multi-jurisdictional partnerships to focus on water quality problems, community-by-community and watershed-by-watershed. These watershed approaches are likely to result in significant restoration, maintenance and protection of water resources throughout the United States. As was reported in the initial *National Sediment Quality Survey* in 1997, various programs across the United States as part of the National Estuary Program have used a watershed approach that has led to specific actions to address contaminated sediment problems. These include the Narragansett (RI) Bay, Long Island Sound, New York/New Jersey Harbor, and San Francisco Bay Estuary programs. These specific programs have all recommended actions to reduce sources of toxic contaminants to sediment.

Recommendations

The primary recommendation of this report to Congress is to:

- ***Encourage further investigation and assessment of contaminated sediment.*** States and tribes, in cooperation with EPA and other federal agencies, should proceed with further evaluations of the 88 watersheds containing APCs. In many cases, it is likely that much additional investigation and assessment has already occurred, especially in well-known areas at risk for contamination, and some areas have been remediated. If active watershed management programs are in place, these evaluations should be coordinated within the context of current or planned actions. Future assessment efforts should focus on areas such as the water body segments located within the 88 watersheds containing APCs that had 10 or more sampling stations classified as Tier 1. The purpose of these efforts should be to gather additional sediment chemistry and related biological data, and to conduct further evaluation of data to determine human health and ecological risk, to determine temporal and spatial trends, to identify potential sources of sediment contamination and determine whether potential sources are adequately controlled, and to determine whether natural recovery is a feasible option for risk reduction.

Other recommendations resulting from the NSI evaluation include the following:

- ***Continue to Promote Watershed Management Programs to Address Sediment Contamination.*** Watershed management is a critical component of community-based environmental protection using watershed or hydrologic boundaries to define the problem area. EPA recommends that federal, state, tribes, and local government agencies pool their common resources and coordinate their efforts to address their common sediment contamination issues. These activities should support efforts such as selection of future monitoring sites, setting priorities for reissuance of NPDES permits, permit synchronization, TMDL development, and potential pollutant trading between sources.

- ***Develop Better Coordination Within the EPA on Activities and Research in the Contaminated Sediments Area.*** EPA developed the *Contaminated Sediment Management Strategy* (USEPA, 1998) in 1998. Building upon the *Strategy*, EPA's Contaminated Sediment Management Committee (CSMC) is developing the *Contaminated Sediment Action Plan*. This Plan will outline the next steps for the Agency in the management of contaminated sediments. This multi-media, cross-program plan will describe the commitments from the EPA program offices to develop and apply sound science in managing contaminated sediments. A key component of future coordination within EPA in addressing sediment contamination is the contaminated sediment assessment pilots. The Office of Solid Waste and Emergency Response (OSWER), the Office of Water (OW), and the EPA's Regional Offices will initiate pilot projects to facilitate cross-program coordination on contaminated sediments. The pilot projects will bring a cross-Agency focus to identifying and assessing waters that are impaired by sediment contamination. The pilots will utilize the legal authorities and techniques available to satisfy the needs of both the Remedial Investigation/Feasibility Study (RI/FS) evaluations and Total Maximum Daily Load (TMDL) modeling. EPA is also developing an Agency-wide Contaminated Sediment Science Plan to identify and prioritize the Agency's contaminated sediment science needs.
- ***Continue to Develop Better Monitoring and Assessment Tools.*** The sediment quality evaluation tools used and outlined in this report should be used as the basis for future contaminated sediment assessment methods. As sediment quality data becomes more available and the state of the science for sediment assessment keeps evolving, better assessment methods will also evolve. As new and better sediment screening values and biological assessment techniques become available and proven to be reliable, EPA will incorporate them into future NSI data evaluations.
- ***Incorporate a Weight-of-Evidence Approach and Measures of Chemical Bioavailability Into Sediment Monitoring Programs.*** The ideal assessment methodology would be based on matched data sets of multiple types of sediment quality measures to take advantage of the strengths of each measurement type and to minimize their collective weaknesses. As the state of science is constantly evolving, EPA recommends that whenever possible, future sediment monitoring programs collect tissue residue, biological effects (i.e., toxicity, histopathology), and biological community (e.g., benthic abundance and diversity) measurements along with sediment chemistry. Collection of measures of chemical bioavailability is critical to the success of weight-of-evidence assessments. Where metals are expected to be a concern, sediment monitoring programs should collect AVS and SEM measurements. EPA also recommends that future monitoring programs also include TOC measurements wherever organic chemicals are a concern.
- ***Continue to Increase the NSI's Coverage.*** The NSI database is currently limited in terms of the number of data sets it includes and the national coverage it provides. The focus of additional data additions will be to: 1) obtain a greater breadth of coverage across the United States, and 2) increase the number of waterbodies evaluated. This type of data will be extremely useful in future analyses to assess the changes in the extent and severity of sediment contamination over time. As part of the initial *National Sediment Quality Survey*, the EPA included the data used for that report in its comprehensive GIS/modeling system, Better Assessment Science Integrating Point and Nonpoint Sources (BASINS). EPA is currently working on getting the additional data in the NSI database into BASINS. In addition to this effort, EPA is also working with NOAA to incorporate the NSI database into Query Manager which is a database program that can be used to access sediment data (chemistry, toxicity, and tissue residue data) for individual watersheds to query and analyze the data.
- ***Assess Atmospheric Deposition of Sediment Contaminants.*** The relative contribution of contaminants to the sediment from air deposition has been virtually unknown on a national scale, but could be significant. Under Section 112(m) and Section 129 of the Clean Air Act, the EPA in cooperation with NOAA has been conducting a program to assess the contributions and effects of hazardous air pollutants on the Great Lakes, Lake Champlain, the Chesapeake Bay, and near-coastal

waters. The findings and conclusions from these reports will be incorporated in future iterations of the *National Sediment Quality Survey*.

This and future *National Sediment Quality Survey* reports will provide environmental managers at the federal, state, and local levels with valuable information. The NSI and this report can assist local watershed managers by providing data, and demonstrating the application of a weight-of-evidence approach for identifying and screening contaminated sediment locations. It also allows researchers to draw upon a large data set of sediment information to conduct new analyses that will continue to advance the science of contaminated sediment assessments that can ultimately be applied at the local level to assist environmental managers in making sediment management decisions.